TECHNICAL NOTE

FEASIBILITY OF USING EASTMAN KODAK TYPE 3400 FILM FOR HIGH ALTITUDE MULTISPECTRAL PHOTOGRAPHY

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Prepared By

Lincoln Perry

Photoscientist

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Photographic Technology Division

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FOR HIGH ALTITUDE MULTISPECTRAL PHOTOGRAPHY

This report has been reviewed
and is approved.

SUBMITTED BY:

Lincoln Perry, Photoscientist

APPROVED:

Gerard E. Sauer, Supervisor
Photo Science Office

APPROVED:

Noel T. Lamar, Technical Monitor

CONCURRENCE BY:

John R. Brinkmann, Chief
Photographic Technology Division

TEST PROCEDURE

Successive passes were made over each site at 15,000, 30,000, and 60,000 feet with the camera configurations listed in Table 1. Atmospheric conditions were relatively clear at both sites.

TABLE I

Camera Configuration

Camera Number	Focal Length	Shutter Speed	Film Type	Filter
Hass. 5R1	80mm	1/60	2402	47B
Hass. 5R2	80mm	1/60	2402	58
Hass. 5R3	80mm	1/60	2402	25
Hass. 5R4	80mm	1/60	3400	47B
Hass. 5R5	80mm	1/60	3400	58
Hass. 5R6	80mm	1/60	3400	25
Zeiss 5L	12in.	1/250	2914	12

The type 2402 film was processed to the standard gamma of 1.4, and the type 3400 film was processed to a gamma of 2.0. All processing was done in a Versamat processor with MX-641 chemistry. Subsequently, duplicate positive transparencies of all rolls were made with matched density levels.

One roll of GAF 2914 was shot with a Wratten 12 filter in an RC-8 camera, simultaneously with the Hasselblads, and processed in Versamat MX-641 chemistry to a gamma of 2.0.

RESULTS

Because of the higher process gamma, the type 3400 imagery exhibited greater contrast, detail, and apparent sharpness. Unfortunately, the slow shutter speed limited resolution to such an extent that type 3400 film shows little resolution improvement over type 2402 film. The slight improvements observed are attributed mainly to the increased gamma. Since it is impossible to achieve a gamma greater than about 1.7 (with 47B and 58 filters) with type 2402 film in MX-641 chemistry, a film such as type 3400 must be used for the higher gammas.

The advantages to be expected from type 3400 film are:

1. lower granularity
2. increased resolution
3. enhanced image contrast.

The one disadvantage of film type 3400 is its lower speed which necessitates larger lens aperatures, which can cause increased vignetting with the 40mm lenses.

The GAF 2914 film exhibited excellent detail and contrast. Reproduction resulted in excellent prints and duplicate positives. The film possesses greater latitude which would be a definite advantage in any earth resources application.

In Figure 1 aerial image modulation (AIM) curves are plotted for both type 3400 and 8401 films. AIM curves for type 2402 film were not available, but should be very similar to those for type 8401. Also plotted in Figure 1 are the system modulation

curves for two different conditions. These curves represent the modulation incident on the film as a function of spatial frequency. The intersection points of the AIM curves and modulation transfer curves represent the system resolution.

Due to the large amount of contrast-reducing haze, photography from the RB-57 would be most closely represented by the two curves at 1.6:1 contrast ratio. These curves assume an altitude of 60,000 feet and a ground speed of 400 knots. The curves were derived by cascading an 80% diffraction-limited f/8 lens optical transfer function with the image-motion transfer function (sin x/x).

RECOMMENDATIONS

1. Use of 1/60 second shutter speed should be avoided, especially with the 80mm lenses. Shutter speeds of 1/125 second or higher will provide an increase in resolution as shown in Figure 1.

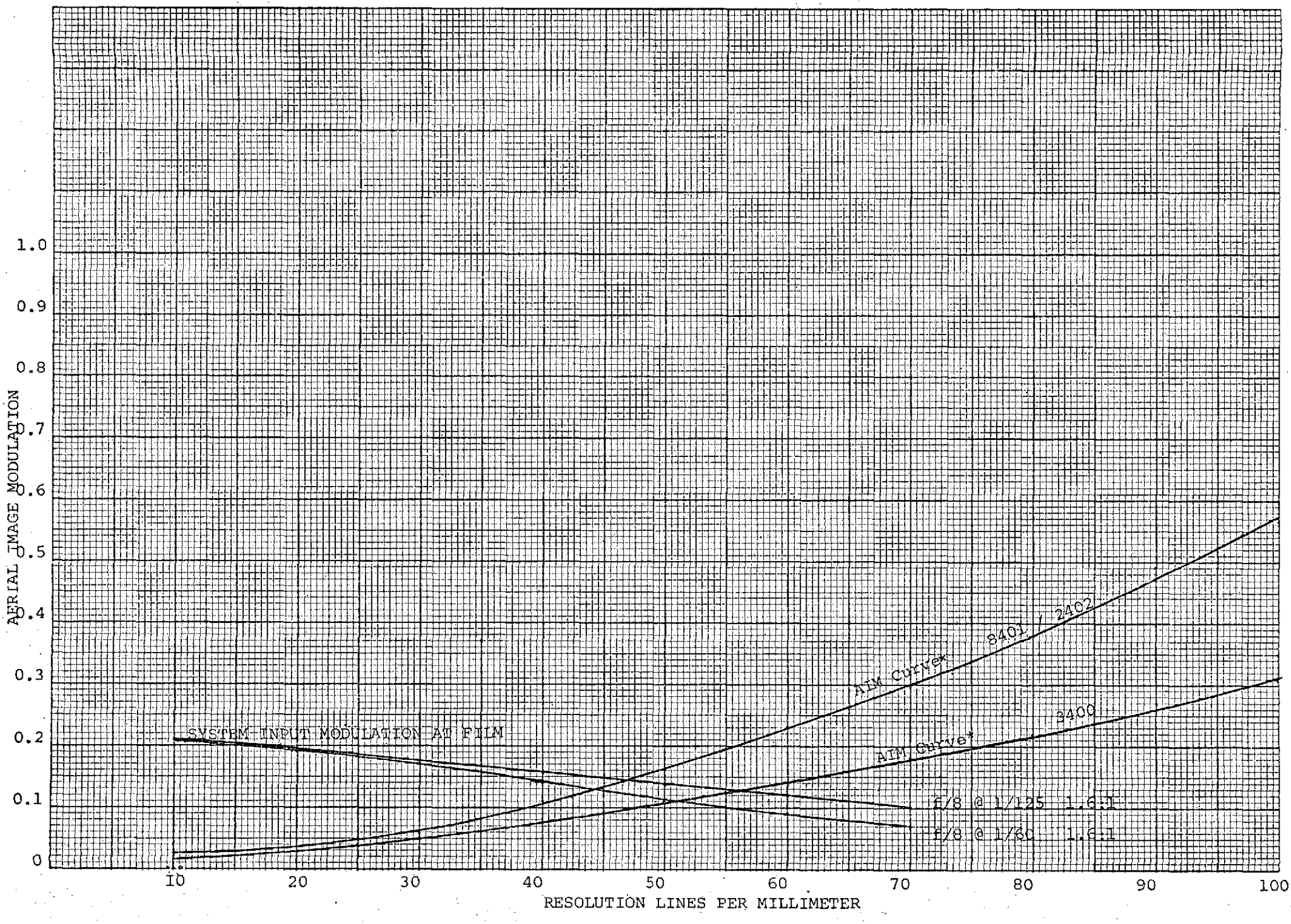
2. Use of f/16 or smaller apertures should be avoided since their diffraction limited resolution is less than 110 lines per millimeter. Since film resolution is normally the limiting factor in this system, apertures larger than f/8 will not increase resolution appreciably, but only increase vignetting.

3. Type 3400 film should be substituted for type 2402 film for higher altitude photography. For a shutter speed of 1/125 second at an altitude of 60,000 feet, the improvement in resolution is about 20%.

4. When exposure conditions necessitate the use of type 2402 film, it should be processed to as high a gamma as possible. GAF film 2914 would permit even higher process gammas than 2402. Table II indicates that aerial image contrast does not exceed 3:1 even at 15,000 feet. This was determined by a microdensitometer scan of the imagery taken over West Texas, which included both rural and urban areas.

5. The processing of three filter records must be changed in order to compensate for the different contrast reduction effects of the atmosphere on multispectral photography. Table III illustrates that for photography at 60,000 feet, the blue record process gamma should be 50% higher than that of the green and red records.

FIGURE 1 - SYSTEM RESOLUTION @ 60,000 feet with 40mm LENSES



* AIM curves from Perkin-Elmer
Photographic Film Data - July 1967

TABLE II

Aerial Image Contrast

Filter	Altitude (feet)	ΔLog E	Contrast Ratio
47B	15K	0.35	2.2
47B	30K	0.28	1.9
47B	60K	0.21	1.6
58	15K	0.43	2.7
58	30K	0.42	2.6
58	60K	0.31	2.0
25	15K	0.43	2.7
25	30K	0.36	2.3
25	60K	0.32	2.1

TABLE III

Process Gammas Necessary for Multispectral Photography

Altitude (feet)	Δ Log E Ratio G/B	Δ Log E Ratio R/B	Average Δ Log E Ratio	*γ_R	*γ_G	*γ_B
15K	1.23	1.23	1.23	1.4	1.4	1.7
30K	1.50	1.29	1.40	1.4	1.4	2.0
60K	1.48	1.52	1.50	1.4	1.4	2.1

*Gamma necessary to produce approximately equal image contrast in all three records (for spectrally neutral targets). Base gamma of 1.4 for red and green records is arbitrary. Differential processing can take place either in original or dupe stages.